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Linking Household Food Security and Food Value Chains in North West Mt. Kenya

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Abstract: Smallholder farmers and pastoralists produce the largest proportion of food consumed in sub-Saharan Africa. However, they remain among the food insecure populations. This paper explores the food (in)security among smallholder farmers and pastoralists using a sample of 175 households in three agro-food value chains of wheat, dairy, and beef in the north-west Mt. Kenya region. The study seeks to answer if a farmer's participation in a particular agro-food value chain determines his/her food security situation. We use the Household Food Insecurity Access Scale (HFIAS) and two Poisson regression models, parsimonious and full, to assess the household food security status and determinants of food security among the smallholder farmers and pastoralists. The results show that 61% of the households were either mildly, moderately, or severely food insecure. Households in the beef value chain experienced relatively higher incidences of food insecurity compared to households in the wheat and dairy value chains. The HFIAS scores revealed a wide gap between households with minimum and maximum score. Household size, income and income-related variables (ability to save and borrow to meet family needs), transport assets, membership in farmers' associations, and household energy were significant in determining household food security, while access to credit and to extension services was not. Strategies that focus on boosting smallholder farmers' incomes, building strong and resilient farmers associations to improve inclusive and equitable value chains have the potential to get smallholder farmers out of recurrent food insecurity.

Keywords: smallholders; pastoralists; poisson regression; beef; wheat; dairy

1. Introduction

Since the first global food summit, a lot of effort has been made towards ensuring that "all people, at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" [1]. This effort has made remarkable progress. However, there are still at least 821 million undernourished people in the world, a third of whom are in sub-Saharan Africa [2]. In Kenya, 30% of the total population is undernourished, a proportion that has remained the same for the past 10 years [3]. As in most developing countries, food insecurity is more prevalent in the rural areas of Kenya. Evidence has shown that Kenyan rural households have higher food poverty incidences, higher micronutrient deficiencies and lower

dietary diversity than the national averages [4]. Smallholder farmers and pastoralists comprise the majority of these food-insecure rural households [5]. Yet they produce the bulk (80%) of food nationally, demonstrating their importance to food security [6,7]. Smallholder farmers are commonly defined based on a threshold of two hectares of land [6]. Other defining features of smallholder farmers include low returns, selling low shares of their farm output, having low shares of non-farm income, simple technologies and reliance on family labor [8,9]. Pastoralists are defined by their unique features of livestock mobility and communal management of resources [10].

Smallholder farmers and pastoralists have the potential to enhance food security by making food available through production, reducing the cost of food through the increase in food supply while generating incomes for farmers and wage workers that allow access to food [11]. But smallholder farmers and pastoralists find difficulties in achieving food security: their productivity remains low, hampered by factors such as a lack of access to markets, credit, inputs, extension services and low farm gate prices [8,12,13]. Moreover, the emergence of new challenges, e.g., from climate change, is increasing the vulnerability of smallholder farmers and pastoralists to food insecurity by exposing their livelihood assets to climate variability and extremes [2]. In fact, climate variability has been associated with the transitory nature of food security. Evidence has shown that the level of food insecurity among smallholder farmers and pastoralists escalates during periods of drought and heavy rains [14,15]. Understanding and addressing these constraining factors is key in achieving smallholder and pastoralists' productivity and food security outcomes, which is the reason for the focus on smallholder farmers and pastoralists.

Differences exist in the level of food security between smallholder farmers and pastoralists in different regions and value chains [4,14]. These food security variations are influenced by economic factors (farm inputs, access to credit and markets, crop diversity, land size, type of agro-ecological zone), demographic factors (household size, education, gender), income and remittances, household assets, and social factors which have been shown to be associated with smallholder farmers food security [4,7,16]. The direction and magnitude of the relationship between these factors and food security vary across studies [17–21]. However, there is limited knowledge on the variations across value chains, information that would best inform target (value chain)-based interventions and strategies. This then underscores the importance of decomposing these variables among different value chain sub-groups.

To address this, we (i) assess the state of food security among smallholder farmers and pastoralists in the wheat, dairy and beef value chains in the north-west Mt. Kenya region; (ii) explore the factors determining their food security; and (iii) examine the differences in the food security status and indicators. Comparison of the food security status and determinants of food security among the smallholder farmers and pastoralists seeks to explain the variations in food security. At the same time, it seeks to establish whether a farmer's participation in a particular agro-food value chain determines his/her food security situation. In so doing, this paper addresses the continuous need to investigate food security challenges, providing the much needed evidence for strategy and policy decisions.

This particular study is part of a larger research project [22] for which the three agro-food value chains of wheat, dairy and beef were selected based on their spatial, social and economic importance and in further consideration that they produce food for the national and regional markets. The region north-west Mt. Kenya was selected for this study because it is characterized by different climatic zones that support different farming systems. It therefore presented a suitable area for a comparative study of different value chains in the same geographical sphere.

2. Materials and Methods

2.1. Study Area

The study was undertaken in the north-west Mt. Kenya region, an area that lies between latitude 0°18′ S and 0°30′ N; and longitudes 36°70′ E and 37°30′ E, extending approximately 5000 km^2 north-west of Mt. Kenya. The gradient of the area declines sharply from an altitude of 5199 m above sea

level (masl) at Mt. Kenya to 1700 masl in the lowlands to the north-west. Similarly, the rainfall pattern varies with the altitude. Areas bordering the slopes of Mt. Kenya receive between 750 and 1200 mm of rainfall, reducing to 400–500 mm in the Laikipia plateau to the north west [23]. There are two rainfall seasons in the area; the long rains, which occur from mid-March to May, and the short rains in October and November. The annual mean temperature ranges between 16 and 26 °C. Population density is high (152 persons per km^2) near Mt. Kenya due to its agricultural potential, and reduces towards the north west to 17 persons per square kilometer, where land becomes drier and less cultivable [23].

The different agro-climatic zones (humid, semi-humid, semi-arid) support different land use activities including pastoralism, agro-pastoralism, large scale ranching, smallholder mixed farming, and large scale farming [23,24]. Mixed farming is done predominantly by smallholder farmers, growing mainly wheat, barley, maize, beans, Irish potatoes and vegetables on an average of two acres of land [25]. Crop production is largely rain fed for both smallholder and large-scale farmers. Livestock production is an important source of livelihood in the study area. Smallholder farmers practice dairy farming, keeping an average of 5 dairy cattle (mainly local breeds) as part of mixed farming [15]. Beef production is carried out in the lowlands to the north-west by large scale ranchers and pastoralists. There are 48 large scale ranches and 13 community ranches occupied by pastoralists [26].

2.2. Sampling and Data Collection

Sampling of households in the three agro-food value chains was carried out as part of sampling of four value chain activities (production, trade and distribution, processing, and retailing) for each of the agro-food value chains for the larger research project. Given this complexity, the study adopted a multi-stage stratified random sampling as shown in Table 1. In total, 175 smallholder farmers and pastoralists were selected as part of producer groups in wheat, dairy and beef value chains that were stratified based on their scale of production.

Table 1. Summary of the sampling procedure.

Study Area	North West Mt. Kenya		
Determination of Study Sites	5 administrative sub-locations in 4 administrative locations based on areas that predominantly produce wheat, milk and beef		
Value Chain Actors	Wheat producers	Dairy producers	Beef producers
Derivation of Sampling Frames	Random sample of 7 (out of 15) large-scale wheat farmers	Random sample of 5 (out of undetermined number) dairy co-operatives	Random sample of 6 (out of 13) community ranches
Generation of Sub-Samples	Random (and snowball) sample of smallholder wheat farmers within 20 km radius of the sampled large scale farms	Random sample of smallholder dairy farmers using a list of 100 active farmers generated from the sampled co-operatives	Random sample of pastoral households using a list of 150 pastoralists generated from the sampled community ranches
Sub-Sample Size	Fifty-eight smallholder wheat-producing households	Fifty smallholder diary-producing households	Sixty-seven beef-producing pastoralist households
Total Sample	One hundred and seventy-five smallholder farming and pastoralist households		

The study began by identifying the specific study sites from which the producer samples would be drawn. Four administrative locations (Ngusishi, Kisima, Umande and Ethi) within the larger study area where wheat and milk are predominantly produced were first identified through key informants. Five sub-locations (smallest administrative unit) were then selected from the four locations. These were: Mutarakwa and Maritati sub-locations in Ngusushi location; Buuri sub-location in Kisima location; Kalalu sub-location in Umande location; and Ethi sub-location in Ethi location. Figure 1 presents the study area and sampled sites.

The 175 smallholder farmers and pastoralists were determined as follows: first, seven large scale wheat farmers in the five sub-locations were randomly selected, and 58 smallholder wheat farmers within a 20 km radius were identified through a combination of random and snowball sampling. Snowball sampling was used to expand the list of smallholder wheat farmers initially generated from key informant interviews with local agricultural and administration officers. Second, 50 smallholder

dairy farmers were randomly selected from a list of 100 active farmers generated from five selected dairy co-operatives. Lastly, pastoralists were selected from the community ranches in the Laikipia plateau, north-west of the study area. Six community ranches were randomly selected, from which a list of 150 households was generated with the assistance of resource persons and the leaders of the community ranches. From this list, 67 households were selected for the study.

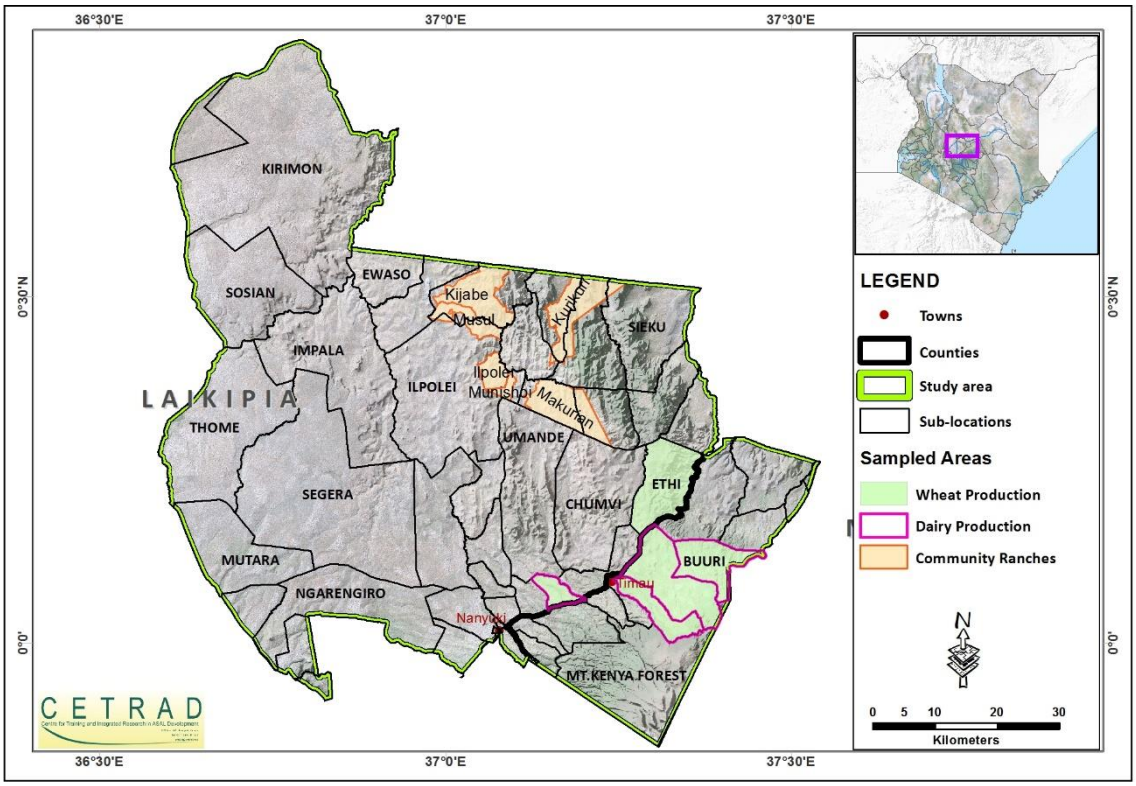

Figure 1. The study area and sampled sites (source: Centre for Training and Integrated Research in ASAL Development).

The surveys were undertaken between the months of October and December 2016 and April and May 2017. Questionnaires were administered face-to-face with the help of enumerators. This provided the best mode of delivery due to the lack of an established mailing system and to increase the response rates. The questionnaires collected data on food production, markets and prices, access to credit, household income, assets, expenditure, demographics, and household food security.

2.3. Analysis

Data analysis was done in two parts. First, we categorized households into either food secure or food insecure; and second, we analyzed the determinants of household food insecurity. The Household Food Insecurity Access Scale (HFIAS) indicators were used to distinguish between food-secure and food-insecure households, while Poisson regression models were used to analyze the determinants of household food insecurity. The smallholder farmers' and pastoralists' households were classified into four sub-groups based on their participation in the three food value chains (wheat, dairy and beef). These are (i) beef producers, also referred to as pastoralists; (ii) smallholder wheat farmers; (iii) smallholder dairy farmers; and (iv) smallholder wheat and dairy farmers. Category four refers to smallholder farmers who participate in both wheat and dairy value chains.

Data used in calculating the HFIAS indicators were collected through the Food Insecurity Experience Scale (FIES), a food insecurity assessment tool developed by the Food and Agriculture Organization (FAO) through the Voices of Hungry project (VOH) [27]. The FIES is an experience-based

scale built on the responses of peoples' experience and behavior regarding food insecurity. The scale consists of a set of eight occurrence questions that broadly fall into three domains of food insecurity: anxiety and uncertainty about food access, insufficient quality of food, and insufficient quantity of food (see Table A1 in Appendix A) [28]. Each occurrence question was followed by a frequency-of-occurrence question to establish how often the condition of the "occurrence question" happened in a month. The scale offers flexibility in adoption and use; thus, this study used a three month recall period and two options for frequency-of-occurrence (once per month and more than once per month). The scale was adapted to measure food insecurity at the household level.

Using the guidelines provided by Coates et al. [28], the study calculated two HFIAS indicators: Household Food Insecurity Access Scale Score (HFIAS), a continuous variable, and Household Food Insecurity Access Prevalence (HFIAP), a categorical variable. Occurrence questions were labelled 1–8 and frequency-of-occurrence questions 1a–8a. Where the answer to the occurrence question was "no", the frequency-of-occurrence was coded 0. Where the occurrence question was "yes", the frequency-of-occurrence was subsequently coded as 1 for "once per month" and 2 for "more than once per month". The HFIAS score was calculated by summing up the frequency-of-occurrence codes, which gives a continuous measure of the degree of food insecurity with households obtaining scores of between 0 and 16. Thus, households whose response to all occurrence questions was 'no' had a minimum score of zero, while those whose response to all eight frequency-of-occurrence questions was 2 had the maximum score of 16. The higher the score, the more food insecurity the household experienced.

HFIAP was calculated in two steps. First, we calculated a Household Food Insecurity Access (HFIA) category variable for each household by assigning a code for the food insecurity category each household fell under. The result is a categorical indicator of food insecurity where each household is placed in either of four mutually exclusive categories: food secure, mildly, moderately, and severely food insecure (Table 2). Second, we calculated the percentage of households that fall in each of the four food security categories by dividing the number of households in a particular category by the total number of households with a HFIA category, multiplied by 100.

Table 2. Calculation of household food insecurity access categorical variable.

HFIA Categories	Calculation
Food secure	HFIA category = 1 IF (Q1a = 0 or Q1a = 1) and Q2 = 0 and Q3 = 0 and Q4 = 0 and Q5 = 0 and Q6 = 0 and Q7 = 0 and Q8 = 0
Mildly Food Insecure	HFIA category = 2 IF (Q1a = 2 or Q3a = 1 or Q4a = 1) and Q2 = 0 and Q5 = 0 and Q6 = 0 and Q7 = 0 and Q8 = 0
Moderately Food Insecure	HFIA category = 3 IF (Q3a = 2 or Q4a = 2 or Q5a = 1 or Q6a = 1) and Q2 = 0 and Q7 = 0 and Q8 = 0
Severely Food Insecure	HFIA category = 4 IF Q5a = 2 or Q6a = 2 or Q2a = 1 or Q2a = 2 or Q7a = 1 or Q7a = 2 or Q8a = 1 or Q8a = 2

Source: Adapted from Coates et al. [28].

The study used two types of Poisson regression models, a parsimonious and a full model. The dependent variable in both models is the HFIAS score, a count variable. The parsimonious model, which is a short model, has four independent variables: pastoralists, dairy farmers, wheat farmers; and dairy and wheat farmers. A household is placed exclusively in either one of these four categories, that they received revenue from. The category dairy and wheat farmers aims to find out whether farmers engaged in two value chains are significantly better in the context of food security. The beef category is used as the baseline comparison group in the model. The objective of the parsimonious model is to describe the behavior of the aggregate value chain sub-groups. The full model used a set of variables that are theoretically considered as determinants of food security. The variables were selected based on a review of the relevant literature and research studies. These variables are defined in Table 3.

Table 3. Definition and measurement of variables.

Variable	Definition and Measurement
vc_type	Value chain type (1 = beef, 2 = dairy, 3 = wheat, 4 = wheat and dairy)
no_cattle	Number of cattle
dist_sellingpoint	Distance to the selling point (km)
access_extservices_yesno	Access to extension services (1 = yes, 0 = otherwise)
membership_org	Membership to farmers group (1 = yes, 0 = otherwise)
contact_ngos	Contact with Non-governmental organizations (1 = yes, 0 = otherwise)
share_equipmentstools	Sharing equipment and tools (1 = yes, 0 = otherwise)
access_credit_yesno	Access to financial credit (1 = yes, 0 = otherwise)
logdaily_income	Daily income (KES)
income_diversity	Number of income streams
no_hhmembers	Number of household members
access_electricity	Access to electricity (1 = yes, 0 = otherwise)
enough_income2save	Enough income to make a saving (1 = yes, 0 = otherwise)
borrwmeet_family_needs	Does household borrow to meet needs (1 = yes, 0 = otherwise)
own_mobilephone	Own mobile phone (1 = yes, 0 = otherwise)
own_bicycle	Own bicycle (1 = yes, 0 = otherwise)
own_motorcycle	Own motorcycle (1 = yes, 0 = otherwise)
own_television	Own television (1 = yes, 0 = otherwise)
HFIAS score	Food insecurity score (range 0–16)

The models were implemented in Stata 14. Multicollinearity was tested with variance inflation factors (VIF). All independent variables had a VIF of less than five, and were thus retained in the model. The Breusch–Pagan test was used to check for heteroscedasticity. The test for goodness-of-fit on the model indicated that data did not fit well due to overdispersion. All other assumptions for Poisson regression were met. As a result of violation of the assumption that counts must have a Poisson distribution, negative binomial regression was used to fit the models. A one unit change in the independent variables results in a change in the logs of the expected counts of the dependent variable by the change in the respective regression co-efficient. The sign of the coefficient in the models show the direction of influence of the independent variable on the dependent variable. Accordingly, a positive value indicates an increase in the HFIAS score, which indicates an increase in the likelihood that a household is food insecure.

3. Results

This section presents the study results in terms of the three main aspects of the objectives. These are (i) socio-economic characteristics of the sampled households; (ii) household food security levels in terms of the household food insecurity access scale and household food insecurity access prevalence; and (iii) the determinants of household food insecurity.

3.1. Socio-Economic Characteristics of Sampled Households

Table 4 presents the descriptive statistics of selected socio-economic characteristics of the sampled households. These characteristics are important in the analysis and understanding of the determinants of household food security presented in Section 3.3. The average household size in all the value chains was five persons. Pastoral households had larger households (six members) compared to the other three sub-groups, which had an average of four persons per household.

Pastoralists owned, on average, more than double the average number of cattle owned by smallholder farmers in the wheat and dairy sub-groups. Livestock keeping was the primary means of livelihood for the pastoralists. Smallholder farmers combined different agricultural and non-agricultural activities to diversify their income. The smallholder dairy and wheat farmers had at least four different sources of income from the production of different crops, livestock keeping and off-farm income from salaries and businesses. The study identified at least 10 different types of crop

grown by smallholder dairy and wheat farmers, among them maize, beans, peas, French beans, barley, tomatoes, carrots, onions, fruits and vegetables such kale and cabbage. Pastoralists' households had less income sources, averaging two, from livestock keeping, salaries and business activities. The most common livestock for both pastoralist and smallholder farmers included cattle, sheep, goats and poultry. The farm was the most important source of income for all sub-groups contributing between 60% and 70% to the total income.

Table 4. Characteristics of sampled households for each value chain.

	Beef	Dairy	Wheat	Dairy and Wheat	All Value Chains
Dependent Variable					
Average HFIAS score	13	2	2	3	5
Independent Variables					
Means (continuous variables)					
Number of cattle (TLU)	14	4	2	5	6
Distance to selling point (km)	4	1	0	0	1
Daily income (total of all income streams, KES)	575	3479	1408	2366	1957
Number of income streams	2	4	4	5	4
Household size	6	4	4	4	5
Categorical variables (%)					
Access to credit	26.9	39.3	16.7	37.5	30.9
Access to electricity	1.5	53.6	29.2	51.8	29.7
Borrow to meet family needs	85.1	39.3	37.5	55.4	61.7
Enough income to save	35.8	82.1	75.0	76.8	61.7
Own mobile phone	85.1	100	100	100	94.3
Own television	20.9	78.6	83.3	91.1	61.1
Membership to farmers group	10.4	92.9	29.2	69.6	45.1
Own bicycle	4.5	57.1	37.5	50.0	32.0
Own motorcycle	22.4	21.4	41.7	26.8	26.3
Contact with NGOs	7.5	14.3	20.8	30.4	17.7
Contact with government	46.3	32.1	29.2	32.1	37.1
Share equipment and tools	94.0	10.7	8.3	7.1	41.1
Access to extension services	53.7	57.1	25.0	41.1	46.3

However, the contribution of beef value chain to the pastoralists' farm income was high (60%) compared to the contribution of wheat (17%) and dairy (21%) to the smallholder farmers farm income. This indicates that pastoralists had fewer income sources and thus relied heavily on beef production. On the other hand, smallholder wheat and dairy households have the possibility of generating additional income from producing a wide array of crops. Hence, they have a lower reliance on these value chains as their main sources of farm income. Households had an average daily income of KES 1960 (Table 4), with the pastoralists having the lowest (KES 575) and the smallholder dairy farmers the highest (KES 3480). The majority (62%) of the households reported not having enough income to save. These households resorted to borrowing in order to meet family needs. Furthermore, only about 30% of the households had access to financial credit.

This study revealed a diversity of assets owned by the households across the different value chain sub-groups. The most commonly owned asset was the mobile phone, owned by 94% of the households, followed by television (61%), bicycles (32%), and motorcycles (26%) (Table 4). Less than 40% of the households were in contact with governmental and non-governmental organizations, and more than half (55%) were not members of any producers' association. In terms of travel to respective selling points, the dairy farmers covered an average distance of one kilometer (km), while pastoralists had a longer (4 km) distance to cover. Wheat, and wheat and dairy-sub groups did not cover any distance because they sold their produce at the farm.

3.2. Household Food Insecurity Access Scale Score and Household Food Insecurity Access Prevalence

Majority of the smallholder farmers in wheat (67%), dairy (61%), and dairy and wheat (52%) sub-groups had the minimum Household Food Insecurity Access Scale (HFIAS) score of zero (Table 5). The majority of the pastoralists (52%) in the beef value chain sub-group had a HFIAS score of 16, the maximum score which a household can achieve. The average HFIAS score for beef sub-group was more than six times higher (13) than that of dairy (2), wheat (2) or dairy and wheat (3) sub-groups (Table 4). These results reveal that most smallholder farmers in the wheat and dairy value chains experienced less food insecurity compared to most pastoralists, who experienced more food insecurity. Without regard for value chain sub-groups, most households fell either under the minimum (37%) or maximum (20%) HFIAS score.

Table 5. Percentage of pastoralists and smallholder farmers for each household food insecurity access scale score.

HFIAS Score	Beef	Dairy	Wheat	Dairy and Wheat	All Value Chains
0	4.5	60.7	66.7	51.8	37.1
1	0.0	3.6	4.2	1.8	1.7
2	1.5	10.7	4.2	10.7	6.3
3	0.0	0.0	8.3	1.8	1.7
4	3.0	7.1	8.3	8.9	6.3
5	0.0	0.0	0.0	0.0	0.0
6	7.5	3.6	0.0	5.4	5.1
7	0.0	0.0	0.0	5.4	1.7
8	7.5	7.1	0.0	0.0	4.0
9	0.0	0.0	0.0	0.0	0.0
10	1.5	7.1	4.2	8.9	5.1
11	1.5	0.0	0.0	1.8	1.1
12	4.5	0.0	0.0	1.8	2.3
13	7.5	0.0	0.0	1.8	3.4
14	6.0	0.0	4.2	0.0	2.9
15	3.0	0.0	0.0	0.0	1.1
16	52.2	0.0	0.0	0.0	20.0

The Household Food Insecurity Access Prevalence (HFIAP) indicator showed that almost half of the households were severely food insecure (46%), 39% were food secure, while 15% experienced either mild or moderate food insecurity (Table 6). Households that were severely food insecure experienced the worst conditions of food insecurity, such as cutting back on the number and size of meals; running out of food, or going a whole day or night without eating [28]. On the contrary, households that fell under the food secure category did not experience any condition related to food insecurity or rarely experienced worry. The beef sub-group had the majority of the households (90%) in the severely food insecure category, while the dairy, wheat, and dairy and wheat sub-groups had the majority of the households, 64%, 71% and 54%, respectively, in the food secure category; a similar result to the HFIAS scores. Households that were either mildly or moderately food insecure were compromising on the quality of food by, sometimes or often, eating a monotonous diet, less preferred foods or less healthy and less nutritious diet, while rarely cutting back on quantity of food [28].

Table 6. Household food insecurity access prevalence for beef, dairy and wheat value chains.

HFIAP Categories	Beef	Dairy	Wheat	Dairy and Wheat	All Value Chains
Food secure	4	64	71	54	39
Mildly food insecure	0	11	4	11	5
Moderately food insecure	6	11	13	13	10
Severely food insecure	90	14	13	23	46

3.3. Determinants of Household Food Security

The estimated parameters for the determinants of food security are presented in Table 7. The parsimonious model suggests that households in the wheat, dairy, and wheat and dairy sub-groups were less likely to experience food insecurity compared to households in the beef value chain. In the full model, households in the wheat value chain were less likely to be food insecure.

Table 7. Determinants of household food security.

	Parsimonious Model		**Full Model**	
HFIAS score	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Dairy value chain	−1.827 ***	0.276	0.003	0.600
Wheat value chain	−2.003 ***	0.300	−1.173 **	0.539
Dairy and wheat value chain	−1.482 ***	0.212	−0.112	0.548
Household size			0.128 ***	0.047
Income diversity			−0.034	0.078
Log daily income			−0.333 ***	0.115
Access to credit			0.079	0.190
Borrow to meet family needs			0.499 **	0.195
Enough income to save			−0.510 ***	0.165
Number of cattle			0.010	0.010
Own bicycle			−0.423 *	0.241
Own mobile phone			0.285	0.309
Own television			−0.051	0.260
Own motorcycle			0.164	0.198
Membership to farmer group			−0.402 *	0.232
Access to extension services			−0.384	0.237
Contact with NGOs			0.201	0.262
Share equipment and tools			−0.517	0.360
Distance to selling point			0.018	0.033
Access to electricity			−0.587 **	0.258
Contact with government			0.398	0.247
Own solar panel			−0.558 ***	0.206
Share knowledge			0.321	0.300
_cons	2.538 ***	0.135	3.512 ***	0.878
Lnalpha _cons	0.131	0.176	−0.561 **	0.220
N	175		175	
Chi^2	65.266		131.163	
r^2_p	0.066		0.133	
P	0		0	

Significance level * 0.10 ** 0.05 *** 0.01; beef value chain (base category).

Household size, income and income-related variables (ability to save and borrowing to meet family needs), transport assets (bicycle), social capital (membership to farmer groups), and household energy (solar panels, electricity) were significant in determining household food security. Household size was significant at 99% confidence levels and was positively related to food insecurity. This implies that large households were more likely to be food insecure. The severity of food insecurity increased with increasing household size. The average household size among households that were food secure, mild, moderately, and severely food insecure was four, five, five and six household members, respectively.

Income-related variables—income, ability to save, and borrowing to meet family needs—were significant in the model. The variable log income and ability to save were negatively related to food insecurity. This suggests that households with higher income and capable of saving money were less likely to be food insecure. Food-secure households had an average daily income of KES 3195, which decreased to KES 1440 among mild and moderately food insecure households and further decreased to KES 568 among severely food insecure households. The survey results show that, on the

one hand, on average 62% of households were able to save money. However, this varied widely when individual subgroups were considered, with the beef sub-group having the lowest (35%) number of households able to make savings compared to the dairy sub-group (82%), dairy and wheat sub-group (77%) or wheat sub-group with 75%. On the other hand, the households that borrowed in order to meet their needs were more likely to be food insecure. This category accounted for about one-third (38%) of the households, the majority (85%) of them being in the beef sub-group, while the fewest (38%) were in the wheat sub-group.

Ownership of transport assets such as a bicycle was a significant determinant of food security. Households that owned a bicycle were less likely to be food insecure. On average, 48% of the households in the wheat and dairy sub-groups owned a bicycle, compared to only 5% of the beef sub-group. Access to household energy, through either electricity or ownership of solar panels, was significant, and negatively related to food insecurity. This implied that households that had access to electricity or owned solar panels were more likely to be food secure. In this regard, about one-third (30%) of the households had access to electricity, while 58% owned solar panels. However, the beef sub-group had almost no (2%) access to electricity and less than half (40%) of the households owned a solar panel.

Social networks through membership to farmer groups and associations was significant at 0.1% and had a negative relationship with food insecurity. This implies that households who are members of a farmer group are more likely to be food secure. The study results show high levels of social networking in the dairy sub-group, where 93% of the households belonged to the so-called dairy farmers' co-operative societies. The study revealed that member dairy farmers benefitted through linkage to larger markets in the urban centers, access to financial credit, enabling access to credit on agricultural inputs, extension services and training.

Variables such as income diversity, access to extension services and sharing of production assets were included in the model. The results reveal that although these variables were not significant, they had a negative relationship with food insecurity. Similarly, household assets such as television, mobile phone, cattle, access to credit and distance to markets were not significant in the model.

4. Discussion

Analysis of household food insecurity suggests that the majority of pastoralist and smallholder farmers are food insecure. This confirms the results of earlier studies that found smallholder and pastoralists households in the rural areas of sub-Saharan Africa as being among the most food insecure [5,7]. However, food insecurity indicators suggest that pastoralists are more food insecure compared to smallholder wheat and dairy farmers. Pastoralists live in the arid and semi-arid lands (ASALs) that are drier than the humid and semi-humid agro-ecological zones where the smallholder wheat and dairy farmers largely live. Previous studies [29,30] have reported high rates of food insecurity among households in the ASALs compared to the less food insecure households in the humid and semi-humid agro-ecological zones [31].

In addition, humid and semi-humid agro-ecological zones support a wide variety of agricultural activities compared to the ASALs, which are only suitable for livestock keeping, making pastoralists heavily dependent on livestock [4]. Moreover, ASALs are vulnerable to climatic shocks such as droughts which impact on pastoral livelihoods and often result to food insecurity [32]. Drought conditions prevailing in the study area, at the time of this study, seemed to have had a greater impact on pastoralists' households who live in the drier parts to the north compared to smallholder wheat and dairy farmers in the humid and semi-humid area on the foot slopes of the mountain. Pastoralists reported loss of livestock due to the scarcity of pasture and water as a result of the drought.

Contrary to the expectation that smallholder farmers in both dairy and wheat farming would be more food secure, due to the ability to combine two income streams, smallholder farmers in either wheat or dairy production were more food secure. A possible explanation for this would be that productivity of an activity may matter more than the number of activities a farmer is engaged in.

However, the activity mix may matter more than number of activities, and therefore smallholder farmers should endeavor to find a mix that earns higher returns [21].

Income was a significant determinant of food (in)security, confirming earlier findings by Maziya et. al. [17] that the higher the household income, the more food secure a household is likely to be. The low levels of income in the beef sub-group could therefore explain the high levels of food insecurity among the pastoralists. Pastoralists are largely dependent on livestock income, as was confirmed by the high contribution of beef income to farm income compared to the smallholder wheat and dairy farmers. Silvestri et al. [21] found that the contribution of livestock to a household's income decreased with higher levels of food security. Pastoralists had a higher number of cattle than smallholder wheat and dairy farmers. Livestock is regarded as an asset and measure of wealth particularly among the pastoral communities [33]. However, this type of asset seems not to contribute to improved food security. Unexpectedly, the number of cattle was not significant and had a positive relationship with food insecurity. Similar results reported by Silvestri et al. [21] found an inverse relationship between livestock and food security, with no significant difference in livestock asset ownership between the food secure and insecure households. Pastoralists have been observed to sell only few livestock primarily when in need of cash to meet household expenses [34,35]. This could imply that (i) livestock have a minimal contribution to household assets among the pastoralists; and (ii) livestock contribution to food security is only a means of last resort and only in times of calamity.

The food-secure households had a smaller household size compared to the food-insecure households, a result consistent with earlier studies [20,36,37]. Evidence has shown that larger household sizes increase the probability of food insecurity by exerting more pressure on consumption than contribution of labor to production [38]. Moreover, large households have been found to increase the dependency ratio, thus aggravating food insecurity [20].

Membership to farmer groups was significant for food security, underpinning the important role of social capital. This confirms the results of earlier studies [20,39,40] that found that membership to farmer groups matters regarding food security. Farmer groups and associations, particularly among smallholder farmers, have been found to be providers or enablers of marketing and access to financial and extension services [41]. Membership to farmer groups was particularly high among smallholder dairy farmers who are organized into groups commonly known as dairy co-operatives. Evidence shows dairy co-operatives to be among the most successful co-operatives in Kenya [42]. Contrary to our expectation, access to credit had a positive relationship with food insecurity, though it was not significant. Similar results were reported by Maziya et al. [17] and Abafita and Kim [36]. This result points to the possibility that credit obtained by households was not necessarily put into productive use. As GOK [43] found, of the few pastoral households that seek credit, the majority borrow for subsistence rather than investment. This would mean that the amount of money diverted to servicing such credit becomes less available income for the purchase of food. Hence, such households end up more food insecure, despite accessing credit.

Household assets such as bicycles and solar panels and access to electricity were significant for food insecurity. This agrees with the study by Kassie et al. [39] that found that the ownership of a bicycle had a positive impact on food security. As an asset that makes local travel easier, a bicycle therefore aids the transportation of farm produce, facilitates access to markets and information, and eases farmers' movement to meetings and events such as trainings. A household's ability to access energy and utilities is considered an indicator of wealth; and a wealthy household is always food secure. This could perhaps explain why the ownership of solar panels and access to electricity was significant for food security.

5. Conclusions

While smallholder farmers and pastoralists make an important contribution to food security in sub-Saharan Africa, they constitute a considerable proportion of the food insecure. Therefore, focusing on these sub-groups not only presents an opportunity to understand why they remain food insecure but also prospects of finding possible pathways for improving their food security status. Four key findings have emerged from our study, which have the potential to inform policy debate towards promising options and pathways for improving food security for smallholder farmers and pastoralists.

First, smallholder farmers and pastoralists remain vulnerable to food insecurity. These households are domiciled in the rural areas of Kenya and are primarily involved in production of food, which forms their main source of income. Furthermore, the majority of the food-insecure households were in the severely food insecure category compared to the mild and moderate food insecure categories.

Second, our results point to existence of a wide gap of inequality in food security status between producer households of the wheat, dairy and beef value chains. Majority of the households in wheat and dairy value chains were food secure, while the majority of the households in the beef value chains were severely food insecure. This confirms that not all smallholder farmers and pastoralists are the same in terms of food security situation which varies depending on the type of food production each is involved in. Therefore, intervention strategies should be differentiated accordingly. However, more focus for equitable and inclusive value chains should be directed to the pastoralists who are more food insecure.

Third, smallholder farmers that combine two production activities are not necessarily more food secure than those involved in a single value chain. This suggests that improving the earnings of a specific production activity would arguably have more impact on improving food security than increasing the number of activities per se. Moreover, low farm-gate prices for perishable products can be improved through strong farmers' associations that engage in storage and processing, for instance of milk.

Finally, key factors contributing to food security include household size, income and income related variables, transport assets, social capital and household energy. These different factors are important in explaining the variations in food security among different households. Interventions and policies should be informed by an understanding of factors that contribute most to the vulnerability of farmers and pastoralists to food insecurity. Notably, there were wide differences in incomes between the highest (smallholder dairy farmers) and lowest (pastoralists) income earners. The significance of income as a determinant of food security suggests that enhancing farmers' income can have a profound impact on improving food security. Moreover, strategies focusing on enhancing production capacities, strong farmers associations and economic resilience have the possibility of improving food security by boosting production earnings.

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Appendix A

Table A1. Food insecurity experience scale.

In the Past Three Months,	No = 0 Yes = 1 DK * = 3 DA ** = 4	If Yes, How Often Did This Happen 1 = Once per Month 2 = More than Once per Month	Domains of the Food Insecurity Construct	Assumed Severity of Food Security
1 Did you worry that your household would not have enough food due to lack of money or other resources?			Uncertainty and worry about food	Mild
2 Did your household lack food due to lack of money or other resources?			Insufficient food quantity	Moderate
3 Did your household not eat healthy food due to lack of money or other resources?			Inadequate food quality	Mild
4 Did you or any household member eat a low diversity of foods due to lack of resources to obtain other types of food?			Inadequate food quality	Mild
5 Did you or any household member skip breakfast, lunch or dinner because there was not enough food, lack of money or other resources?			Insufficient food quantity	Moderate
6 Did you or any other household member eat less than he/she should because there was not enough food, lack of money or other resources?			Insufficient food quantity	Moderate
7 Did you or any household member feel hungry but did not eat because of lack of food, money or other resources?			Insufficient food quantity	Severe
8 Did you or any household member eat only once a day or go a whole day without eating anything because there was not enough food, lack of money or other resources?			Insufficient food quantity	Severe

Source: Adopted from Ballard et al. [27], Coates et al. [28]; Notes: * DK—Don't Know, ** DA—Didn't Answer.

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